ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

DRAFT FINAL
Soil Action Levels
Technical Memorandum

Rocky Flats Environmental Technology Site
10808 Highway 93
Golden, CO 80403-8200

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ACRONYMS

AL	Action Level
ALF	Action Level Framework
CAD	Corrective Action Decision
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	Contaminant of Concern
CRA	Comprehensive Risk Assessment
DOE	U.S. Department of Energy
EPA	Environmental Protection Agency
FS	Feasibility Study
IHSS	Individual Hazardous Substance Site
PCOC	Potential Contaminant of Concern
PRG	Preliminary Remediation Goal
PPRG	Programmatic Preliminary Remediation Goal
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RI	Remedial Investigation
ROD	Record of Decision
RSAL	Radionuclide Soil Action Level
SWD	Soil Water Database
TM	Technical Memorandum

1.0 INTRODUCTION

This Technical Memorandum (TM) addresses the use of radionuclide and non-radionuclide soil action levels (ALs) in making accelerated action determinations and conducting accelerated actions at the Rocky Flats Environmental Technology Site (RFETS, Rocky Flats, or Site) pursuant to the Rocky Flats Cleanup Agreement (RFCA). Soil action levels were originally established in 1996 and were substantially revised in 2003. The 2003 soil action levels also included specific soil action levels for ecological receptors. Thus, accelerated action determinations at the Site were made, and accelerated actions completed, based on either the 1996 or the 2003 soil action levels, depending upon when the determination was made or the accelerated action was taken. This TM also presents the basis for Site-Wide Contaminants of Concern (COCs). The TM has been prepared in accordance with Task 2 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) Report Work Plan (DOE 2001).

RFCA describes the consultation process and decision document submittal process that DOE uses to implement accelerated actions or conduct other mitigating actions at Individual Hazardous Substance Sites (IHSSs). The RFCA processes have provisions for soliciting and receiving public review and comment on the proposed accelerated actions, and for attaining approval from the Colorado Department of Health and Environment (CDPHE) and/or the Environmental Protection Agency (EPA). RFCA adopted this accelerated action approach to Site cleanup for the reasons described in RFCA paragraph 79:

> To expedite remedial work and maximize early risk reduction at the Site, the Parties intend to make extensive use of accelerated actions to remove, stabilize, and/or contain Individual Hazardous Substance Sites (IHSSs).

Accelerated actions also contribute to the efficient performance of the anticipated final remedy for the Site.

2.0 ACTION LEVEL FRAMEWORK (ALF) BACKGROUND

To implement the accelerated action approach, the RFCA Parties adopted numerical ALs for surface and subsurface soils, surface water and groundwater that when exceeded triggered evaluation and it appropriate, required accelerated actions to address contaminants of concern. The ALs for potential contaminants for each media type were developed in 1996 and were listed in Action Level tables in RFCA Attachment 5, *Action Levels and Standards Framework for Surface Water, Ground Water and Soils* (ALF). Consistent with EPA policy and guidance[1], the 1996 action levels for soils were calculated based upon anticipated future land use assumptions, which are described in the RFCA Preamble and RFCA Appendix 9, *The Rocky Flats Vision*. The land use assumptions included both limited industrial and open space uses. The surface soil and subsurface soil ALs were divided into those for non-radionuclides, and those for radionuclides, which were known as "Radionuclide Soil Action Levels" or RSALs.

From mid-1996 until mid-2003, a two-tier system was used for soil ALs to guide the action determination process. If the Tier I action level was exceeded an appropriate accelerated action was evaluated and taken. Soils below Tier II action levels did not trigger any action determination. Soil concentrations between Tier I and Tier II required an evaluation to determine what, if any accelerated action beyond management controls were appropriate based upon consideration of certain factors, such as risks posed to ecological receptors or to surface water quality.

On June 5, 2003, modifications to ALF were approved by EPA and CDPHE. As discussed herein, the modifications included adoption of new soil ALs based on an established risk (no tiers) to a wildlife refuge

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1 See, OSWER Directive 9355.7-04, *Land Use in the CERCLA Remedy Selection Process*, May 25, 1995.

worker, as the reasonably anticipated future land user for the purpose of making cleanup decisions. This was based upon the assumption that a National Wildlife Refuge will be established in accordance with the "Rocky Flats National Wildlife Refuge Act of 2001"[2] (Refuge Act). The ALs are applicable to all soil, surface and subsurface; however, a risk-based approach is used in the application of the ALs to subsurface soils (see *Subsurface Soil Risk Screen,* ALF Figure 3) to assess the need for and extent of accelerated actions. The risk-based approach accounts for the fact that subsurface contamination at the Site poses significantly less risk of exposure to the wildlife refuge worker than surface contamination.

2.1 Radionuclide Soil Action Levels

The 1996 RSALs were dose-based. They were calculated based upon a draft EPA rule, subsequently withdrawn, that specified radiation dose limits for CERCLA response actions involving radionuclide releases.[3] When RFCA was signed in July 1996, a working group was convened to determine the application of the draft EPA rule dose limits and to derive and select appropriate RSALs. The draft EPA rule specified that CERCLA response actions for radionuclides must achieve an annual dose limit of 15 mrem for a restricted anticipated future land use, and an annual dose of 85 mrem for unrestricted land use, the latter provision based upon failure of the assumed land use restrictions. With respect to the restricted anticipated future land use, specific Site areas were identified as either limited industrial use or open space use. Accordingly, the working group developed the exposure scenario and parameters for an office worker (limited industrial use), a recreational user of open space, and for a hypothetical future resident (unrestricted use).

For each restricted land use area, the lowest calculated radionuclide concentration at the annual dose limit for the restricted use and unrestricted use (residential) exposure scenario was selected as the RSAL for Tier I. Given this selection criterion, the RSAL for designated industrial use areas was based on an annual dose of 15 mrem to an office worker, and the RSAL for open space areas was based on the 85 mrem to a hypothetical future resident. Although not driven by the draft EPA rule, the Tier II RSALs were based upon an annual dose of 15 mrem to a hypothetical future resident as a conservative measure.

2.2 Non-Radionuclide Soil Action Levels

The 1996 soil action levels for non-radionuclides in surface soil were based upon lifetime excess cancer risks or toxicity limits, or the potential for organic chemicals in subsurface soils to contaminate ground water above safe drinking water limits.[4] The surface soil action levels for inorganic contaminants (and radionuclides) were also used as the subsurface soil action levels, because in 1996, the RFCA Parties had not yet developed a model and exposure parameters for estimating risks posed by subsurface contamination.[5]

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2 Defense Authorization Act for Fiscal Year 2002, P.L. 107-107, sec. 3171, *et seq.*, 16 U.S.C. sec. 668dd, note.

3 The basis for the 1996 RSALs is described in the Public Review Draft, August 30, 1996, and Final, October 31, 1996, *Action Levels for Radionuclides in Soils for the [RFCA]*. Note that because the draft EPA rule contained a dose limit for unrestricted land use, a residential land use assumption and conceptual model was also used to calculate RSALs.

4 Non-radionuclide surface soil action levels are calculated using excess cancer risk-based or chemical toxicity-based mathematical formulas developed for the open space user and industrial user (office worker) exposure pathways. The methodology and calculated values are described in, *Programmatic Preliminary Remediation Goals Tables*, Appendix N of RFCA Appendix 3, *the Implementation Guidance Document*. The methodology and formula for action levels for organic chemicals in subsurface soils are based on leaching to groundwater and are shown in RFCA Attachment 5, Table 4. For inorganic chemicals in subsurface soil, the surface soil action level was applied. See RFCA Attachment 5, Section 4.2.

5 See, *Action Levels for Radionuclides in Soils for the [RFCA]*, Final, October 1996, Appendix M of the *RFCA Implementation Guidance Document*, RFCA Appendix 3, section 4.4, Subsurface Soil Assessment. Also see, RFCA Attachment 5, Section 4.2 A.2.

For non-radionuclides, Tier I action level concentrations for carcinogens were calculated to a lifetime excess cancer risk[6] of 10^{-4}, and for non-carcinogens, to a Hazard Quotient (HQ)[7] of 1. Tier II action level concentrations were calculated to a lifetime excess cancer risk of 10^{-6} and a HQ of 1. In either case, when both carcinogenic and noncarcinogenic toxicity information was available, both carcinogenic and non-carcinogenic risk-based concentrations were calculated, and the more restrictive value was selected as the AL.

3.0 ALF MODIFICATIONS

Revisions to the RSALs and other modifications to ALF were proposed on November 12, 2002. There were a number of reasons for the modifications.

- RFCA requires a periodic review of new technical and/or regulatory information affecting the action levels.[8]
- Local governments and community members were concerned that the 1996 RSALs were not sufficiently conservative, and questioned the methodology used to establish the RSALs.
- The draft EPA rule for dose-based cleanup of radiologically contaminated sites that was used as the basis for the current RSALs was withdrawn and EPA issued guidance that radionuclide cleanups must meet CERCLA risk-based criteria.
- A new and different dose-based "decommissioning rule" was promulgated by the U.S. Nuclear Regulatory Commission and subsequently adopted by CDPHE that is potentially relevant and appropriate for Site cleanup.[9]
- New technical information relevant to the RSALs became available.
- Under CERCLA policy, cleanup levels are to be consistent with the final reasonable anticipated future land use. With the congressional designation of RFETS as a future wildlife refuge, review of the RSALs was appropriate.

The proposed changes to RSALs and ALs for other contaminants were predicated upon the adoption of a risk-based approach for surface and subsurface soil contamination that was also included in the 2003 ALF modifications. The changes reflected four underlying principles.

- Removal of greater amounts of surface soil contamination will be triggered, because it is easily accessible to a surface future user, may migrate, and removal to reduce these risks is preferred.
- Removal of subsurface contamination, which is less accessible and less mobile than surface soil contamination, will be triggered based on risk to the surface future user arising from potential pathways of exposure to the contamination.
- More surface soil removal and consideration of subsurface pathways will better serve to protect surface water quality to meet surface water standards so that surface water is suitable for all uses.

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6 The risk of cancer is described in terms of the probability that an individual will develop cancer by age 70 because of exposure to cancer causing chemicals. For each chemical of concern, this value is calculated using the daily intake of the chemical from the Site (averaged over a lifetime) and the cancer slope factor for the chemical. The resulting value is an estimate of the number of cancer cases expected in excess of those caused by the daily intake of background or non-site related chemical contamination. A risk level of $1x10^{-4}$ indicates an excess cancer case in one hundred out of one million individuals exposed to cancer causing chemicals at the site, or a 0.01% individual risk of developing cancer from exposure.

7 The potential for non-cancer effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose (RfD) derived for a similar exposure period. A RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. Non-carcinogenic risk for a contaminant is measured as a Hazard Quotient (HQ), which is the quotient of the expected dose of the contaminant received by a receptor to the RfD. An HQ = 1 indicates that a receptor's dose of a single contaminant is unlikely to result in toxic non-cancer effects.

8 See, RFCA Part 20, Periodic Review, and RFCA paragraph 5.

9 See, 10 CFR 20, Subpart E and 6 CCR 1007-1, RH 4.61.

- Recognition that institutional controls and other long-term stewardship activities will be used as appropriate to protect human health and the environment because RFCA accelerated actions are not expected to result in removal of all contamination.

4.0 2003 SOIL ACTION LEVELS

This section describes the rationale for the development of the 2003 soil ALs. A more in-depth discussion can be found in the *Technical Basis Document for the Proposed Modification to the Rocky Flats Cleanup Agreement Attachments to Implement Integrated Risk-Based Accelerated Action Framework*, November 12, 2002.

4.1 Radionuclide Soil Action Levels

Because of questions about the methodology used to establish the historical RSALs and public concern that the radionuclide concentrations were not sufficiently conservative, DOE funded a review of the RSALs through the Rocky Flats Citizen's Advisory Board to the Radionuclide Soil Action Level Oversight Panel (RSALOP). Beginning in 1998, the RSALOP administered an open public process for an independent review of the RSALs conducted by a contractor, Risk Assessment Corporation. As a key part of the review, Risk Assessment Corporation was also tasked to recommend a technical methodology for deriving RSALs and to use the new methodology to independently calculate RSALs, which it did in February 2000. The RSALOP recommended that the RSALs derived by Risk Assessment Corporation be adopted for the Site.[10]

An RSALs Working Group composed of technical experts, toxicologists and health physicists from the EPA and CDPHE, with support from DOE and Kaiser-Hill Company, L.L.C. staffs, also was involved in the RSALs review. The RSALs review was also conducted as an open public process and the RFCA Parties considered public input and recommendations related to the RSAL review. One public forum established to assist the RFCA Parties during the review was the "RFCA Stakeholder Focus Group", which met with the RFCA Parties routinely for approximately 18 months.

The RSAL review was divided into five separate tasks, which resulted in the Task Reports listed below.

- Task 1 Report, Regulatory Analysis.
- Task 2 Report, Computer Model Selection.
- Task 3 Report and Appendices, Calculation of Surface RSALs for Plutonium, Americium and Uranium.
- Task 4 Report, New Scientific Information.
- Task 5 Report, Determining Cleanup Goals at Radiologically Contaminated Sites.

The five Task Reports were grouped into one document, *Results of the Interagency Review of Radionuclide Soil Action Levels*, September 30, 2002.

The 2003 RSALs were selected to achieve a lifetime excess cancer risk not greater than 1×10^{-5} for a wildlife refuge worker. When multiple radionuclides are present, and each individual radionuclide is below its individual action level, a sum-of-ratios calculation is performed to determine whether the action level is exceeded. The 2003 RSALs also meet the decommissioning rule dose-based criteria, which are assumed to be relevant and appropriate to the Site. The RSALs are presented in Table 3 of ALF.

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10 See, *Final Report, Technical Project Summary*, Risk Assessment Corporation, February 2000, and the February 15, 2000, letter from the RSALOP Co-Chairs to the Acting Manager, Rocky Flats Field Office.

4.2 Non-Radionuclide Action Levels

The non-radionuclide action levels were calculated using the Task 3 Report risk-based calculation methodology that was used to calculate the 2003 RSALs. Similar to the 2003 RSALs, the 2003 non-radionuclide soil action levels are based on a $1x10^{-5}$ excess lifetime cancer risk or a non-cancer Hazard Quotient of 1 to a wildlife refuge worker. When both carcinogenic and non-carcinogenic toxicity information was available, both carcinogenic and non-carcinogenic risk-based concentrations were calculated, and the more restrictive value was selected as the AL.

The calculations for the non-radionuclide soil action levels are shown in the *Preliminary Remediation Goals* (PRGs) document.[11] While the risk-based calculation methodology for radionuclides and other analytes is the same, some of the input parameters to the calculation are different. The RSALs and PRGs use all the same exposure assumptions for the wildlife refuge worker, except for the location of the wildlife refuge worker's office. The RSALS assume that the office is located in the contaminated area. The PRGs assume the office is located in an uncontaminated area. The result is that the RSALs include a 4-hour per day outdoor exposure and a 4-hour per day indoor exposure. The PRGs include only the 4-hour per day outdoor exposure. The non-radionuclide soil action levels are presented in Table 3 of ALF.

4.3 Ecological Receptor Soil Action Levels

Ecological receptor soil action levels are chemical specific, risk-based concentrations calculated based on a specific medium (soil) and land use (wildlife refuge) at RFETS. Risk-based concentrations were calculated for several surrogate receptors, judged to be representative of species at RFETS, using toxicological values under specific exposure conditions. The ecological receptor soil action levels represent concentrations that are protective of those receptors that commonly come into contact with soil or ingest biota that live in or on soil.

It is important to note that the ecological receptor soil action levels are initial guidelines. They do not establish a cleanup level, but do trigger the consultative process to evaluate potential accelerated actions.

4.4 Consistency with the Site Final Action

The use of a 1×10^{-5} target risk for soil action levels that are applied to accelerated actions is expected to contribute to the achievement and efficient performance of the anticipated final remedy for the Site. The final remedy for RFETS must meet the CERCLA threshold criteria of a lifetime excess cancer risk to the reasonably maximally exposed individual (the wildlife refuge worker) of between 1×10^{-4} and 1×10^{-6}, and must be compliant with Applicable or Relevant and Appropriate Requirements (ARARs). CERCLA's implementing regulations provide that the lower end of the allowable risk range serve as a point of departure in developing acceptable exposure levels for a final remedy if, due to multiple contaminants and/or multiple pathways, compliance with ARARs does not provide protection within the acceptable risk range. Although there are multiple contaminants and/or multiple pathways at RFETS, it is anticipated that compliance with ARARs and use of the soil action levels for remediation of IHSSs (accelerated actions) will result in a final Site risk within the acceptable CERCLA risk range for the following reasons:

- The final Site risks will be based on exposure units that are much larger than individual IHSSs, and thus encompass low contaminated or uncontaminated soil. Therefore, the actual risk posed by soil in an exposure unit will be significantly lower than the risk posed by soil at an IHSS ($< 1 \times 10^{-5}$).
- Generally IHSSs requiring an accelerated action have only a few COCs present at concentrations above the soil action levels.

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11 The PRG document will replace the current PPRGs document as Appendix N of the *RFCA Implementation Guidance Document*, RFCA Appendix 3.

- When multiple radionuclides are present at an IHSS, the sum-of-ratios method is used to determine the cleanup goal for an accelerated action (the cummulative risk will be $< 1 \times 10^{-5}$).
- The plutonium soil action level actually represents a 5×10^{-6} risk, and plutonium is the most significant contaminant in surface soil. Where plutonium contamination exceeds the action level in surface soil, the soil will be removed to a depth of 3 feet, if necessary, to achieve the action level. This will also remove other non-radioactive contaminants that may be present in the soil.
- Most areas at the Site with the potential to have subsurface soil contamination that could impact groundwater (and thus surface water) have incomplete pathways because of the groundwater barrier/remediation systems that are in place today.

5.0 SITE-WIDE CONTAMINANTS OF CONCERN

In the conduct of a RI/FS, COCs serve as a short list of all constituents detected in environmental media that have been determined to be:

1. Site contaminants present in environmental media, and

2. Occur at concentrations that are above background and risk-based concentrations.

COCs are typically used to streamline risk quantification in the risk assessment and to focus the evaluation of remedial alternatives on those contaminants that are found to dominate risk for the site. COCs for the Site will be established when accelerated actions are nearing completion, and prior to the conduct of the CRA and FS (Detailed Analysis of Alternatives).

Site-Wide COCs have a somewhat different purpose than the COCs described above. Like COCs, the Site-Wide COCs serve to identify (at this time) those constituents that are both wide-spread contaminants and above risk-based concentrations. Accordingly, the main objective in identifying Site-Wide COCs was to ensure data were collected at all IHSSs and in white space areas, as necessary, because their presence in soil was suspected regardless of the types of contaminants that may have been released at specific IHSSs. Because analytical methods typically do not target individual analytes but rather quantify an entire suite of constituents within a given analytical classification, data for non-Site-Wide COCs have also been collected. For example, the identification of beryllium as a COC indicates that metals are a suite of constituents that are analyzed at all IHSSs.

Process knowledge with respect to a waste release at a specific IHSS may indicate the potential for the presence of IHSS-specific COCs not on the Site-Wide list. In these instances, the analytical suites represented by the potential IHSS-specific COCs have been a part of the characterization program for the IHSS.

The following process, which will be used for identifying COCs for the CRA, was used to identify Site-Wide soil COCs. Application of the process to surface and subsurface data for the Site and identification of the Site-Wide COCs is presented in *Identification of Site-Wide Contaminants of Concern Technical Memorandum*, November 11, 2002.

Selection of Site-wide COCs based on protection of human health involved a 5 step screening process. The process eliminated data of inadequate quality, and analytes that 1) were major cations/anions or were otherwise not currently listed in ALF, 2) did not exceed surface soil PRGs, 3) were infrequently detected, 4) were at concentrations that were within background levels, and 5) were not constituents of waste released at RFETS.

Step 1 – Conduct Data Filter and Calculate PCOC Statistics

Characterization data have been collected at the Site for over 15 years. All of the data have been entered into the Soil Water Database (SWD). In this first step, the data were first filtered to identify the Potential Contaminants of Concern (PCOCs). The filtering process served to:

1. eliminate data that was rejected during validation or is Quality Control data;

2. eliminate non-detects that are greater than the maximum detected value in the data set (prevents high bias when calculating the mean concentration because half the detection limit is used as a replacement value for a non-detect); and

3. eliminate analytes that are either essential nutrients, major cations/anions, or otherwise not listed in ALF. The essential nutrients and major cations and anions that are eliminated include iron, magnesium, calcium, potassium, sodium, bicarbonate, carbonate, sulfate, and phosphate

Statistics were then computed for the analytes that remain, i.e., the PCOCs. The statistics included the number of samples (n), the detection frequency, the mean concentration, the standard deviation, and the 95% upper confidence limit (95% UCL) of the mean concentration.

Step 2 – Comparison to Action Levels

PCOC concentrations were compared to the new soil ALs in ALF to eliminate those analytes that did not pose significant risk. Because risks are considered additive when multiple contaminants are present, maximum concentrations of each PCOC were conservatively compared to 10% of the AL. Therefore, the screening criteria to select Site-Wide COCs were a 10^{-6} excess cancer risk or an HQ equal to 0.1. When the ecological receptor AL was lower than the human health-based AL, 10% of the ecological receptor PRG was used as a screening criterion. In order to be conservative, the PCOC maximum concentrations were compared to the ALs.

Step 3 – Frequency of Detection

At this stage of the screening, there are typically many PCOCs that still remain. Many of these PCOCs occur infrequently. Carrying these infrequently detected PCOCs through the risk assessment process distracts from understanding which compounds dominate the risk posed by the site. The screen for frequency of detection was to eliminate PCOCs that occur at a frequency less than 5%.

Because an infrequently detected analyte may be a contaminant present at a significant concentration from a risk perspective, the concentration data for an analyte with a detection frequency less than 5% was further assessed. This assessment involved comparing the maximum concentration of the PCOCs to three times the soil AL. Three times the soil AL is an estimate of a concentration that may result in an acute effect. An acute effect was examined because the occurrence of the analyte is not widespread, and thus a long term (chronic) exposure is unlikely. Only those analytes whose maximum concentrations were less than three times the soil AL were eliminated.

Step 4 - Comparison to Background

In this step, PCOCs were eliminated because they were determined to not be Site contaminants. For naturally occurring constituents (metals and radionuclides), the constituent must have had concentrations that were statistically higher (at the 95% confidence level) than background concentrations. For organic compounds, it was assumed that analytes detected above the method detection limits were contaminants even if they were naturally occurring, or of anthropogenic origin but unrelated to the release of waste into the environment. [In Step 5, professional judgement was used to eliminate organics whose presence did not appear to be a result of waste releases to the environment.] The statistical test used for metals and radionuclides was the non-parametric Mann Whitney test.

Step 5 – Professional Judgement

The professional judgement screen was the final assessment before retaining a PCOC as a COC. Professional judgement was used to ensure that the Site-wide COCs were truly Site contaminants of waste origin. The professional judgement screen included:

1. Process knowledge – Was there information that suggested that the PCOC was not a component of waste generated at the Site?

2. Spatial distribution of concentrations – Did the horizontal and vertical distribution of the PCOC concentrations suggest that a waste release was not responsible for the occurrence of the PCOC?

Professional judgement was only be used to eliminate a PCOC when the evidence strongly suggested that the PCOC was not a contaminant.

6.0 REFERENCES

DOE, 2001, *Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) Report Work Plan*, Golden, Colorado, November.